The values of the radiation potentials for strontium and barium have not been directly determined, but Mohler, Foote and Megers (*Sci. Paper, Bureau of Standards*, No. 403, 1920) give estimates from the wave-lengths of the tail lines of the proper spectral series for these elements. Hydrogen is added to the table, although not given by Eve. An inspection of the table brings out the following:

For Group I, the degree of constancy of the products is nearly the same, being slightly in favor of the use of I rather than (I — R). Group II A, shows, on the other hand, that (I — R) gives a better agreement than I. This is still more marked in Group II B. Group V A is considerably more favorable to (I — R). In case of the inert gases the product using I alone does not hold at all, while the product (I — R) gives nearly a constant. The product using (I — R) places hydrogen in good agreement with the first Group. Mercury, which has some of the physical qualities of the inert gases, has a product about equal to that for those gases. In case of the whole table, going from Group to Group, the products using (I — R) are much more constant than is the case with I alone.

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*PERIODS AND LOGARITHMIC DECREMENT OF THE GRAVITATION NEEDLE UNDER HIGH EXHAUSTION**

BY C. BARUS

DEPARTMENT OF PHYSICS, BROWN UNIVERSITY

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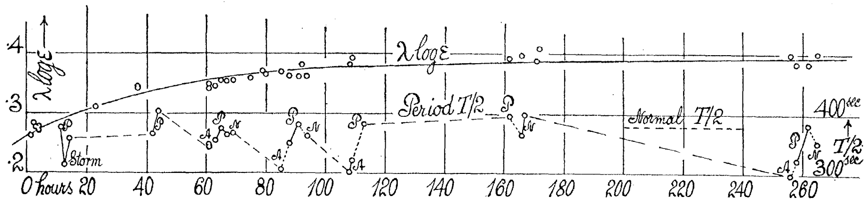
The Deflections.—After a search for a finer quartz fibre than was used in my last paper, one was found giving a double deflection of $\Delta y = 13.42 \pm .03$ cm. as compared with the former 2.67 cm., for the same case and needle. In spite of this astonishing sensitivity and otherwise admirable behavior of the apparatus, the new result for Δy from 30 successive night observations came out relatively less accurate than the former. At the same time, the observations on any single night (details must be omitted here) rarely differed by more than .1%. It is a case therefore in which the increasing importance of the radiation forces renders further finessing with the fibre of doubtful use in the given environment.

Logarithmic Decrements λ log ϵ.—In the endeavor to cope with this formidable difficulty, I began a study of the vibration of the needle in high vacua of a few thousandths of a millimeter; but the summer vanished before I completed it. The results so far obtained are interesting, however, and are given in the attached chart. The case was exhausted in the beginning to about 2.6×10^{-3} mm. on the McLeod gauge, and then sealed off. Air, however, in the lapse of 11 days very slowly leaked in through the glass cock and rubber tubes; and as the installment prevented me from finding the successive vacua (always beyond the U-gauge limit) I have expressed

the results for T and λ in the lapse of time. To determine the latter, the needle was deflected from rest to the maximum elongation, by placing the lead balls M M' in either of the active positions; and with the needle so deflected for an instant, to quickly put the weights in the neutral position again; i.e., in the vertical plane through the needle. It is thus possible to determine both the period T of the needle and the logarithmic decrement: the former by timing successive passages (first and second) through the equilibrium position with a stopwatch, and the latter by reading the elongations. The zero point was nearly constant. The radiation is thus taken symmetrically from both sides. So far as the method goes, the values of T and λ are quite accurately found in this way, the difficulty being in the interpretation. The plenum value of $\lambda \log \epsilon$, so far as determinable in a heated room was about 1, the needle being now practically aperiodic. This has decreased to about .27 (ratio of arcs 1.9) at 2.6×10^{-3} mm. of pressure and the curve suggests a more rapid decrease beyond. With the pressure values added the curve will afford data for the viscosity of highly rarified air.



Periods.—Unlike λ, the values for the period T (figure) show no marked improvement as the vacuum increases. In spite of the steady zero point, they rather vary with the time of day, being smallest in the morning and largest toward the end of the day and they drop off at night (A denoting forenoon, P afternoon, N night). The latitude of values is enormous, ranging from about 10 minutes to over 13 minutes. The former cases (low T) are usually encountered in the morning, and probably indicate repulsive radiant forces acting from the plates toward the middle plane of the case, like an elastic buffer, whereby the period is shortened. Moreover the effect of the changes of λ on T are nearly negligible in comparison with the enormous fluctuations of T resulting from modified environmental radiation.

Whereas the deflections Δy are largest in the morning and least at night, the T values pursue a nearly opposite course, increasing from morning to afternoon, except that the night periods again drop off. When the environmental temperature is gradually increasing (morning) and when it is gradually decreasing (night), small values of T, the period of the needle, occur. This was also shown strikingly during a violent rain storm (chart 11–15 hours), in which the atmospheric temperature dropped about 20° F.

If the case is warmer, the needle meets repulsive agencies toward the center from the excess of radiation inward. If the masses m at the end of the needle are the warmer, the needle radiates toward the case outward and therefore experiences an equivalent repulsive reaction. Finally with a non-uniform radiant field of force, increasing from needle to case, the effect will be virtually an increase of the torsion coefficient, of the quartz fibre, so that T comes out smaller.

It would then follow that the large deflections are obtained when the radiant field is nearly uniform and that the larger values of the period T are the more nearly correct. This finally is in keeping with the γ-values thus obtained.

Finally the deflections Δy are modified and complicated by the screening effect of the presence of the masses M, which in the T experiments are absent.

Estimate of Radiation Temperature-differences.—Let us suppose that the radiant repulsion from case to needle, the elastic buffer effect explained, can be expressed as an increment a_r of the modulus of torsion a, of the needle. Furthermore, if f_r is the radiant force at each end and $\Delta y_r/4L$ half the double deflection in radians, we get a second value of a_r. If we equate the two values

$$f_r = \pi^2(ml/L)\,\Delta T^{-2}.\,\Delta y_r \qquad (1)$$

To find $\Delta 1/T^2$, the least and maximum T found in vacuo in the last paragraph, i.e., $T' = 5$ minutes and $T = 6.5$ minutes, may be inserted, so that the modulus in (1) is 7.0×10^{-4} nearly.

To determine the radiation forces in vacuo, it will be necessary to postulate the case of black body, or full radiation. If θ and θ_0 are the absolute temperatures between which radiation takes place and E the energy radiated (ergs per cm.^{2} per sec.)

$$E = 4K\theta^3\,\Delta\theta$$

The value θ may be taken as $300°$ and $K = 5.3 \times 10^{-4}$. Thus

$$E = 10^3 \times 5.7\,\Delta\theta.$$

This radiation may at the outset be supposed to reach the needle from a single cm.^{2} S, S', of *each* plate situated on the end normal of the needle and plate. Thus eventually, $\rho_0 = E/2\pi c$ (c being the velocity of light) is the energy density or the light pressure at a distance of 1 cm. from the element S or S'. If we suppose (as is nearly the case) the shot m of frontal area A to be situated there, the force f_r upon it will be $\rho_0 A$, where $A = .16$ cm.^{2} Hence

$$f_r = 10^{-9} \times 4.8\,\Delta\theta \qquad (2)$$

for the square centimeter of plate taken.

If now we equate the values of f_r in (1) and (2)

$$\Delta\theta = 150\,\Delta y_r \text{ nearly,} \qquad (3)$$

if but a single square cm. on each glass face radiates toward m. As there are a number of such square cms., contributing radiation, the coefficient of (3) would be decreased ten or twenty times. One may conclude I think that $\Delta\theta$ compared with Δy_r is numerically much in excess. This implies too large a $\Delta\theta$, to persist in a room of practically constant temperature, in the summer. It is thus more than probable that at a vacuum of 10^{-3} mm. or a force of .22 dynes on each shot, so small a part as 10 or 20 times the $10^{-8} \times 70 \times \Delta y_r$ instanced in equation (1) may remain fluctuating in value with small changes in the radiating thermal environment.

Measurement of γ in Terms of the Viscosity of Air.—A maximum deflection of the m-balls is produced by placing the M-balls in position. When this is attained, the latter are reversed and the velocity v with which the needle (filamentary frame) passes through the equilibrium position, is measured with a stopwatch. The M-balls are then again reversed and the measurement of v repeated; etc. In a plenum, the motion of the needle through the zero point is practically uniform and therefore the frictional force is equal to the gravitational pull. Moreover, if two points of the scale near to and equidistant from the zero point are selected for releasing and arresting the stopwatch, the torsion of the fibre acts to the same degree as an acceleration and a retardation.

The frictional resistance encountered by either round mass m of radius r is by Stokes' equation $6\pi\eta rv$, where η is the viscosity of air. The velocity v of the balls m is

$$v = (l/2L)\,\Delta y/\Delta t$$

Δy is the telescopic excursion in the time Δt, symmetrically, to the position of equilibrium. We obtain in this way

$$\gamma = \frac{R^2}{Mm}\,\frac{3\pi\eta rl}{L}\,\frac{\Delta y}{\Delta t}$$

Work on this principle has been actively pursued, but the summer closed before it could be completed.

* Advance note from a Report to the Carnegie Institution of Washington, D. C.

PLANE REFLECTION OF SOUND, AS EXHIBITED BY THE PIN-HOLE RESONATOR*

By C. Barus

Department of Physics, Brown University

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1. *Vertical Reflectors.*—These experiments, made between the walls of a room (y direction), with the closed organ pipe P, vertical, mouth down-